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Fig.1.

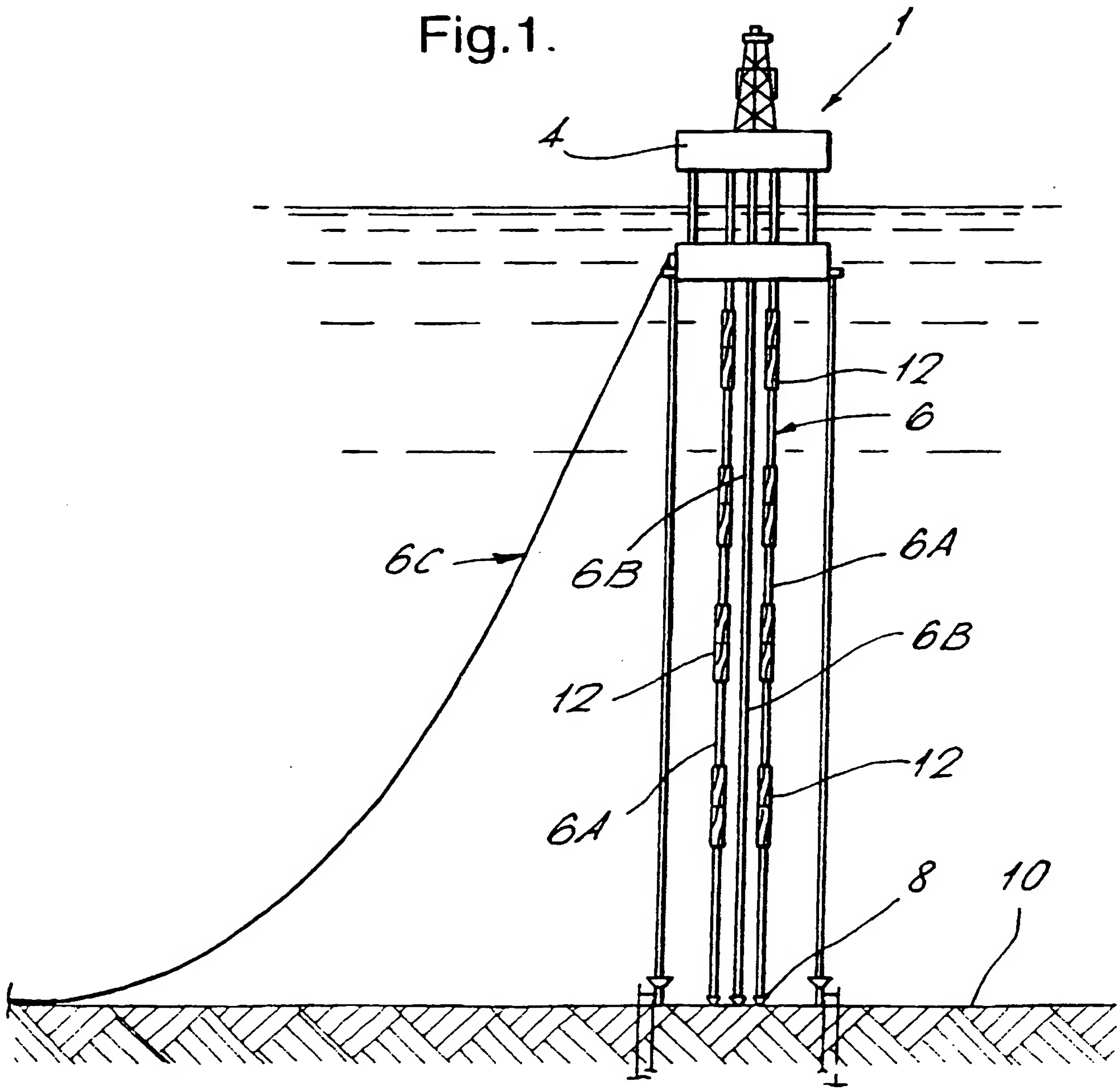


Fig.2.

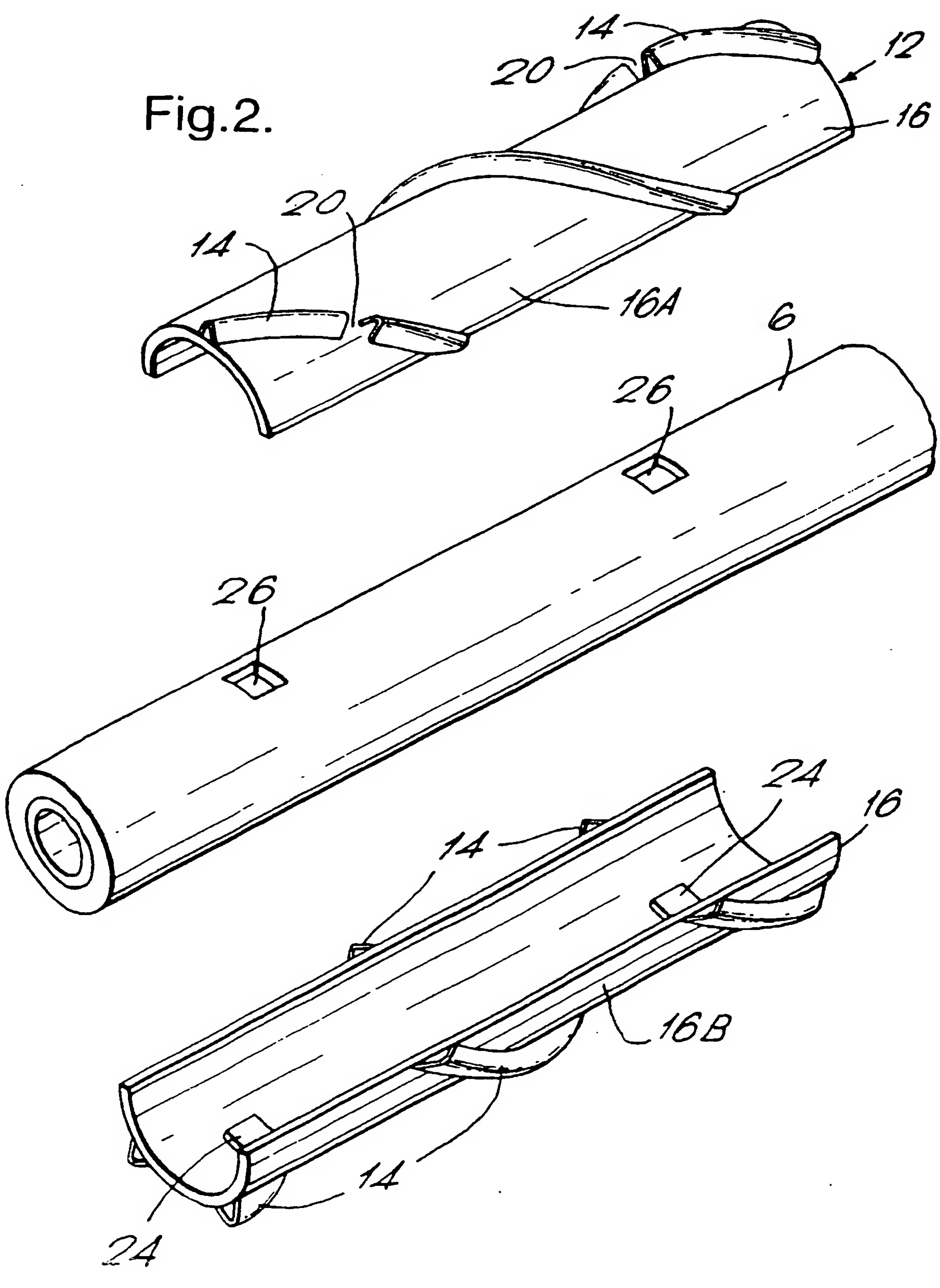


Fig.3A.

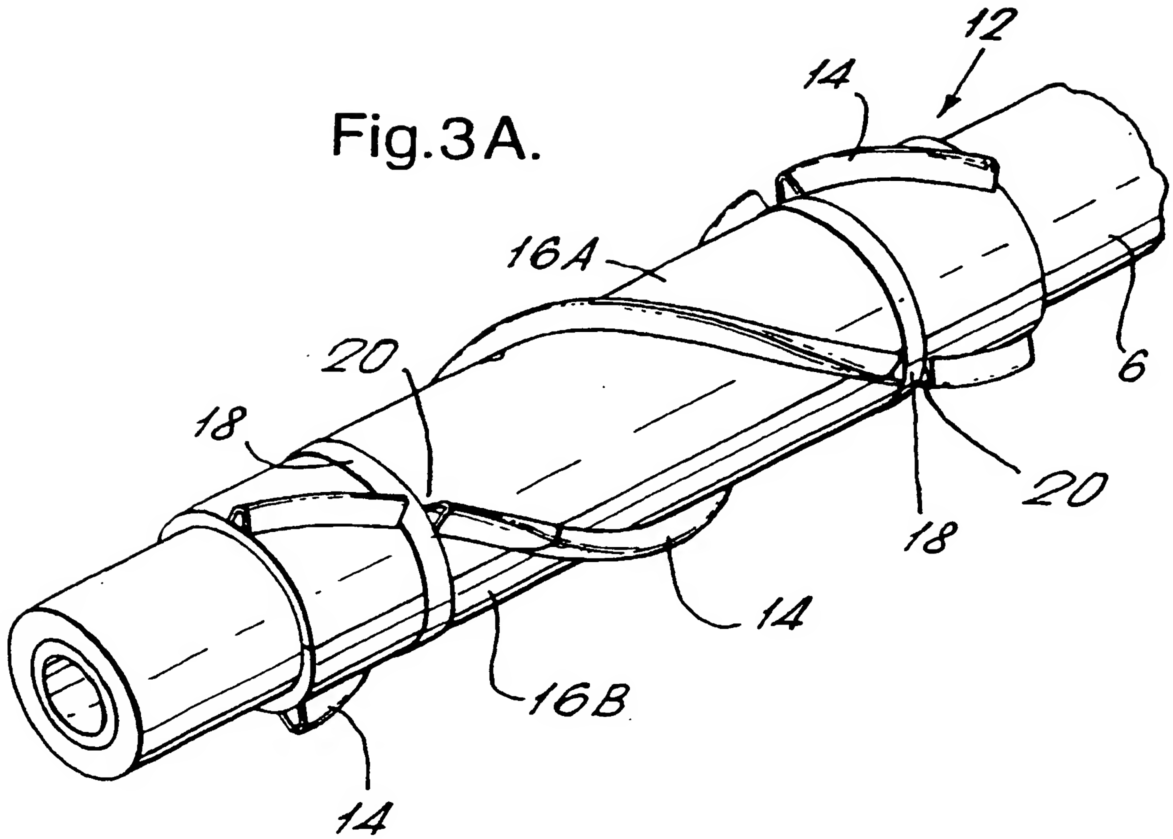
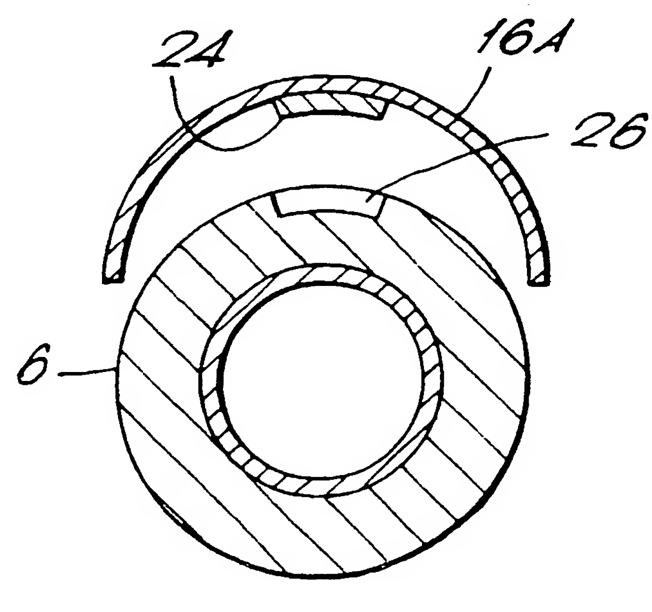



Fig.3B.



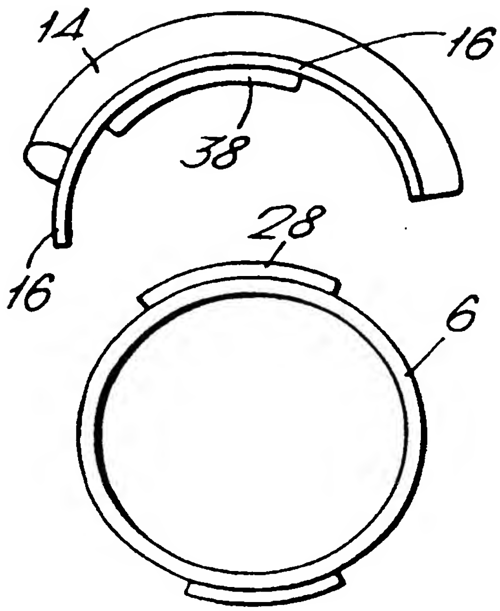



Fig.3C.

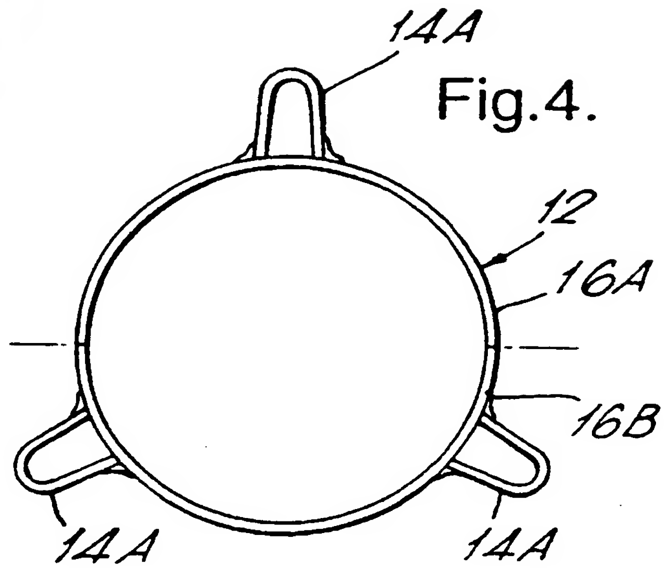



Fig.4.

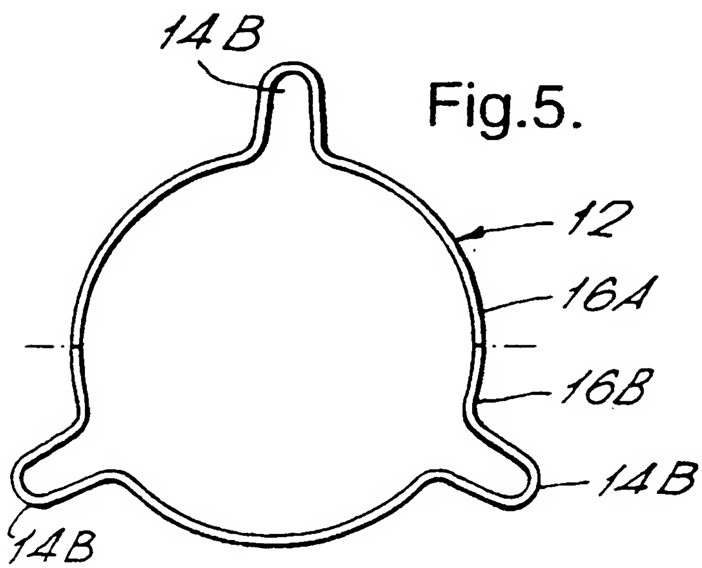



Fig.5.

Fig.6A.

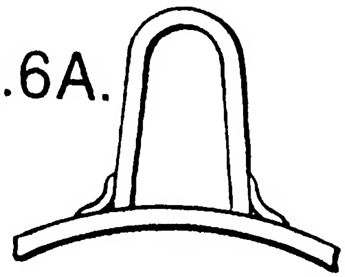


Fig.6B.

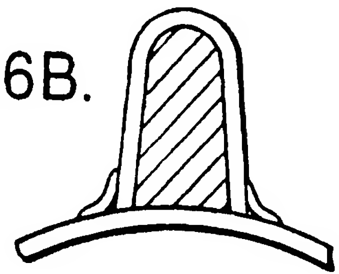


Fig.6C.

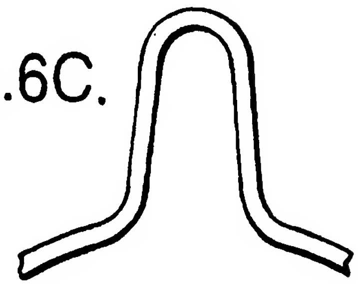


Fig.6D.

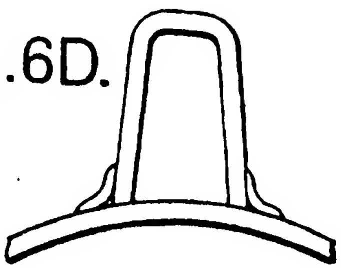


Fig.6E.

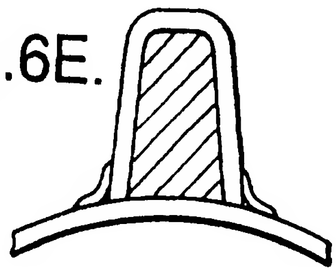


Fig.6F.

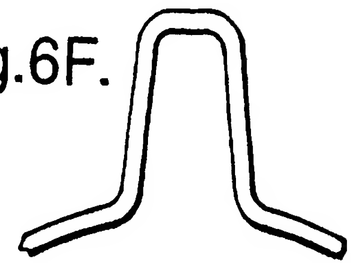


Fig.6G.

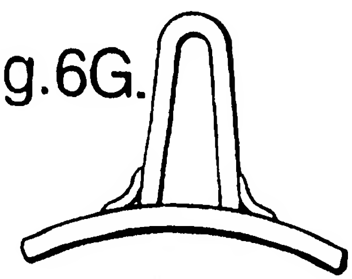


Fig.6H.

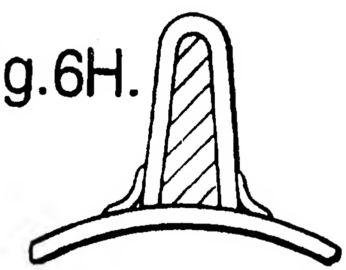
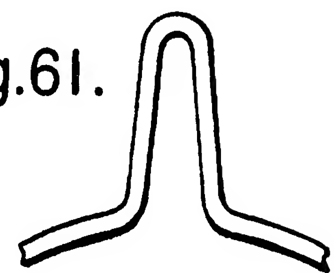


Fig.6I.



2363363



# SYSTEM FOR REDUCING VORTEX INDUCED VIBRATION OF A MARINE ELEMENT

The present invention relates to a strake system for reducing vortex induced vibrations (VIV) of a marine element. A typical example of a cylindrical marine element susceptible of being subjected to VIV is a marine riser for establishing fluid communication between a drilling vessel floating at the water surface and a wellbore extending into the earth formation below the seawater.

When water flows past the riser, vortices are alternately shed from each side of the riser. This produces a fluctuating force on the riser transverse to the current. If the frequency of this harmonic load is near the resonant frequency of the riser, large vibrations transverse to the current can occur. These vibrations can, depending on the stiffness and the strength of the riser and the welds between the riser joint, lead to unacceptably short fatigue lives.

It has been tried to reduce vortex induced vibrations of subsea risers by modifying the boundary layer of the flow around the riser to prevent the correlation of vortex shedding along the length of the riser. Examples of such methods include the inclusion of helical strakes, axial rod shrouds or perforated shrouds around the riser.

However, to arrange strake elements around the cylindrical marine element is generally difficult and expensive.

Accordingly, it is an object of the invention to provide a marine element comprising a cylindrical marine element provided with an improved strake system that can readily be applied to the cylindrical marine element in a cheap and effective manner.

In accordance with the invention there is provided a marine element comprising a cylindrical marine element and a strake system for protecting the cylindrical marine element from vortex induced vibration, which strake system comprises at least two shell members forming a hollow cylinder defining a cylindrical hollow passage for receiving the marine element, which hollow cylinder is provided with a strake extending along the outer surface of the hollow cylinder so as to reduce vortex induced vibrations of the marine element, wherein the cylindrical marine element is arranged in the hollow passage of the strake system, wherein the hollow cylinder of the strake system is provided with a fixing means for engaging the hollow cylinder to the cylindrical marine element, and wherein the fixing means includes at least one of (a) a primary shear tab extending into the hollow passage for engagement with a corresponding primary recess provided at the outer surface of the cylindrical marine element, and (b) a secondary recess provided at the inner surface of the hollow cylinder for engagement with a secondary shear tab provided at the outer surface of the cylindrical marine element.

By the provision of shell members to which the strake is attached, it is achieved that the strake can be

applied to the marine element relatively easily and cheap by applying the shell members to the marine element.

The invention will be described hereinafter in more detail and by way of example with reference to the accompanying drawings in which:

Fig. 1 schematically shows an offshore platform provided with an embodiment of the strake system of the invention;

Fig. 2 shows the strake system of Fig. 1 when in unassembled form;

Fig. 3A shows the strake system of Fig. 1 when assembled around a riser of the offshore platform;

Fig. 3B shows a cross-sectional view of the riser and strake system of Fig. 3A;

Fig. 3C shows a cross-sectional view of an alternative arrangement of the strake system around the riser of;

Fig. 4 schematically shows a cross-sectional view of a pair of shell members to which strakes are welded;

Fig. 5 schematically shows a cross-sectional view of an alternative pair of shell members integrally formed with strakes; and

Figs. 6A-6I schematically show different embodiments of strake systems according to the invention, wherein the strakes of Figs. 6A-6C have a curved outer end;

the strakes of Figs. 6D-6F have a flat outer end;

the strakes of Figs. 6G-6I are relatively thin;

the strakes of Figs. 6A, 6B, 6D, 6E, 6G, 6H are welded to their respective shell members;

the strakes of Figs. 6A, 6D, 6G are hollow;

the strakes of Figs. 6B, 6E, 6H are filled with a suitable material or are solid; and

the strakes of Figs. 6C, 6F, 6I are integrally formed with their respective shell members.

Referring first to Fig. 1, there is illustrated a typical environment in which a strake system of the present invention is deployed. An offshore platform 1, shown here a tension leg platform ("TLP"), includes surface facilities 4, risers 6, including production risers 6A, drilling risers 6B, and catenary risers 6C, and wells 8 at ocean floor 10. As the production risers are not tied to supporting framework, buoyancy cans or flotation modules can be deployed along the length of the riser to increase its buoyancy.

A strake system 12 according to the present invention is installed along the risers 6 to manage VIV problems.

Referring now to Fig. 2, there is shown the unassembled strake system 12 of the present invention prior to positioning on a portion of riser 6. Referring also to Fig. 3A, there is shown the strake system 12 when assembled and positioned on riser 6.

Strake system 12 includes two shell members which, when assembled, form a cylindrically hollow cylinder provided with strakes 14. For ease of construction and installation, it is preferred that the shell members are hemi-cylindrical shaped members 16 shown in Figs. 2 and 3A as first shell member 16A and second shell member 16B.

The shell members 16A and 16B can be assembled together by any suitable method with any suitable means. For example, first and second shell members 16A and 16B

can be provided with a flange along their connecting edges and/or their ends and flanged together, or strips can be arranged across the connecting edges, the strips being either adhesively bonded or bolted into place to secure the shell members 16A and 16B together. For ease of installation, it is preferred that first and second shell members 16A and 16B be assembled together with the use of one or more bands 18. These bands 18 encircle the assembled strake system 12 and extend through cutouts, slots 20 (see Figs. 2 and 3A), or passages provided in strakes 14. The desired number of bands will generally vary with the length of strake system 12, although it is preferred that three bands, one near the middle, and one near each end, be utilized.

Strake system 12 can be held in position on riser 6 by any suitable apparatus and method. As non-limiting examples, strake system 12 can be welded to riser 6, can interlock with, interengage with, or be supported by mechanism affixed to riser 6, can utilize a friction pad, either on strake system 12, riser 6 or both, or can be provided with thrust collars.

Preferably, strake system 12 is provided with at least one shear tab 24 positioned on the shell member within the plane of band 18. This shear tab 24 mates with a complementary shear tab recess 26, formed into a buoyancy layer or insulation layer carried by riser 6, or in riser 6 itself. Fig. 3B is a cross-sectional view of riser 6 showing shear tab recess 26 cut into a buoyance layer of riser 6. The tightening of band 18 urges shear tab 24 to remain in shear tab recess 26, thus preventing movement of strake system 12 along riser 6.

Alternatively, as shown in Fig. 3C, riser 6 can be provided with a tab or ring 28 (i.e. a continuous tab around the riser circumference) which cooperates with

either a recess or tab 38 located on the inside of the shell members 16.

Alternatively again, the shell members 16 can be provided with one or more, preferably a multiplicity of tabs which are capable of extending into, biting, or otherwise penetrating any insulation layer, coating layer or buoyancy layer provided on riser 6.

In the construction of each of the shell members 16, strakes 14 can be affixed to the shell members 16 or be integral therewith. For example, referring now to Figs. 4 and 5, there is shown a side view of assembled strake system 12, with Fig. 4 showing strakes 14A affixed to first and second shell members 16A and 16B, and which Fig. 5 showing strakes 14B to be integral to shell parts 16A and 16B.

Referring to Figs. 2 and 3, each of shell members 16A and 16B comprise portions of strake 14 arranged so that when shell parts 16A and 16B are assembled will result in helically shaped strake 14 as shown.

Strake 14 may be of any suitable or desired geometric shape, profile and configuration, and any desired or suitable number of strakes 14 may be utilized. It is not intended that strake system 12 be limited to any particular geometric shape, profile or configuration for strake 14, or number of strakes 14. It is preferred, however, that strake 14 be helical as shown in Figs. 2 and 3A, with the number of helical strakes and helix angle selected according to the environmental conditions.

Referring to Figs. 6A-6I, it is sometimes desirable to utilize a hollow strake, for example for material cost saving purposes. However, for both externally attached hollow strakes and integral hollow strakes, should the strake material not be sufficiently strong to resist the water force, then either a solid or a filled strake can be utilized.

Regarding materials of construction, strake system 12 can be constructed of any materials suitable for the underwater environment and suitable for supporting the strakes. Additionally, it may be desirable in some instances for strake system 12 to provide buoyancy and/or insulation. It is also possible to first install strake system 12 and then pump an insulating coating material between strake 12 and the riser 6.

In the practice of the present invention, strake system 12 may be provided to riser 6 either pre- or post-installation of riser 6.

In the practice of the present invention, the number of strake systems to be utilized on any given marine element will depend upon the length of each strake system and the length of the marine element to be covered by the strake systems. As a non-limiting example, it would not be unusual to utilize 20, 30 or even 40 strake systems on a riser.

Instead of assembling together the shell members by means of bands, the shell members can be assembled together by applying thrust collars around the shell members, or by bolting the shell members together using studs and fasteners.

While the present invention has been described mainly by reference to risers, it should be understood that it has applicability to a wide variety of marine elements subjected to vortex induced vibrations, such as subsea pipelines, drilling risers, production risers, catenary risers, import- and export risers, tendons for tension leg platforms, legs for traditional fixed and for compliant platforms, other mooring elements for deepwater platforms and so forth.

C L A I M S

1. A marine element comprising a cylindrical marine element and a strake system for protecting the cylindrical marine element from vortex induced vibration, which strake system comprises at least two shell members forming a hollow cylinder defining a cylindrical hollow passage for receiving the marine element, which hollow cylinder is provided with a strake extending along the outer surface of the hollow cylinder so as to reduce vortex induced vibrations of the marine element, wherein the cylindrical marine element is arranged in the hollow passage of the strake system, wherein the hollow cylinder of the strake system is provided with a fixing means for engaging the hollow cylinder to the cylindrical marine element, and wherein the fixing means includes at least one of (a) a primary shear tab extending into the hollow passage for engagement with a corresponding primary recess provided at the outer surface of the cylindrical marine element, and (b) a secondary recess provided at the inner surface of the hollow cylinder for engagement with a secondary shear tab provided at the outer surface of the cylindrical marine element.

2. The marine element according to claim 1, wherein the cylindrical marine element includes at least one outer layer selected from a buoyancy layer and an insulation layer, which outer layer being provided with at least one of the primary recess and the secondary shear tab.

3. The marine element of claim 1 or 2, wherein the strake system further comprises at least one band, which band is circumferentially positioned around the hollow cylinder so as to assemble the shell members together.

4. The marine element of claim 3, wherein the band extends in a plane substantially passing through the at least one of the primary shear tab and the secondary recess.

5. The marine element of claim 3 or 4, wherein the strake is provided with at least one of a cut-out, a slot and a passage, for receiving the band.

6. The marine element of any one of claims 3-5, comprising a first band arranged near one end of the hollow cylinder, a second band arranged near the other end of the hollow cylinder, and a third band arranged substantially centrally in-between the first band and the second band.

7. The marine element of any one of claims 1-6, wherein the shell members of the strake system are designed to provide buoyancy or insulation to the marine element.

8. The marine element of any one of claims 1-7, wherein the cylindrical marine element is selected from the group of a subsea pipeline, an offshore riser, a tendon of a tension leg platform and a mooring line of an offshore platform.

9. The strake system substantially as described hereinbefore with reference to the drawings.